On the formation of interstellar gas clouds

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The characteristic features of interstellar gas clouds - existence of large density fluctuations, their connection with cosmic dust, stretching along the magnetic fields and so on, may be described by the shock wave theory in interstellar space.

The author developed the theory of stationary shock waves accompanied by losses of energy by means of radiation. Choosing two surfaces on both sides of the front, so that the regions of energy radiation should lie between them, we can write an equation of the mass flow and impulse conservation on these surfaces and two equations, which determine the stationary temperature of the gas in the field of interstellar radiation. The solution of this system of equations permits to determine the general changes of thermodynamics and of other parameters for the transition of gas through the shock wave with regions of radiative cooling. If some changes of the degree of ionisation take place and a magnetic field is present, some terms should necessarily be added to the corresponding equations.

The boundary between the interstellar gas cloud and the intercloud medium must represent the shock wave accompanied by losses of energy by means of radiation, because such ruptures may probably be supposed as the sole explanation of stability of the great (for hundred times and more) density changes often observed in the interstellar space.

In this paper we give some results of the theory of shock waves accompanied by losses of energy by means of radiation.

I. The increase of density in such waves is very great, approximately equal to $\rho_2/\rho_1 = v^2/RT_2$, where v - velocity of the wave, T_2 - temperature behind the front. For instance, the shock waves with radiative cooling moving in the HI region with a velocity v about 5 km/sec at a temperature T_2 about 100° causes an increase of density for 30 times. This can take place only if the radiative cooling would be rather powerful. It can be maintained in the region H I by the H_2 molecules forming on the particles of cosmic dust. Therefore sharp increases of density for 30 and more times in the HI region are also taking place when sufficient quantities of cosmic dust is available.

2. The magnetic field (if it is present) also increases in strength very strongly in the shock waves with radiative cooling. $\frac{H_2}{H_1} = \frac{\rho_2}{\rho_1} \sin\varphi_1$, where φ_1 — is the angle between the direction of the magnetic field in front of the shock wave and the normal to this front. Both the magnetic field and the direction of the gas flow behind the front are almost parallel to the front of the considered shock wave. Therefore in dense nebulae (and also in filaments) which are formed by the shock waves the flow of gas is mainly directed along the magnetic field.

3. It is convenient to use the method of automodel streams (selfmodelled streams) for the investigation of the motion of the shock wave system. For instance, the problem os spreading of the rupture of ionisation (of the boundary between (H I) and (H II) regions), considered earlier by Kahn, Savedoff and Green with the aid of other methods, had been solved by the author by means of the method of automodel streams. The shock wave with radiative cooling moving in front of the ionisation wave (rupture), increases the density in the HI region for some hundred times. The ionisation wave decreasing the gas density follows behind. The temperature T_2 and the gas density ρ_0 behind the front of ionisation are the determining parametra of this problem. The region of increased density (H I) expands with time and moves with constant velocity. The gas density in this compressed region

equals approximately 4 ρ_0 T_2/T_0, where ρ_0 and T_0 are the density and temperature of the gas in H I region in front of the shock wave. This system of flow is only possible if the condition $\rho_2 < 2\rho_0$ fulfilled . This is possibly the case of the instability of this system leading to a disintegration of the dense region into separate clouds, as it had been supposed by Oort and Spitzer.

The method of self-modelled solution was also used for an investigation of the motion in a resisting interstellar medium of envelopes ejected by novae or supernovae.

4. In conclusion I should like to make some comments about the connection between the system of cosmic clouds and the interstellar turbulence. According to the author's opinion magneto -gasodynamic turbulence of the different eddies must be more isolated, than in the ordinary turbulence. This hypothesis was suggested to avoid a suppression of motions of the small eddies by the magnetic fields of the big ones. Such suppression contradicts modern statistical picture of turbulence.

If this hypothesis is correct, it is possible to interprete the interstellar gas clouds as more or less isolated eddies of interstellar magnetic turbulence.

References

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